Universidade de Lisboa

Faculdade de Farmácia

Strategies to Reduce Health Inequalities

The Example of COVID-19 Vaccination

Bruno Miguel da Silva Casquilho Alves

Monografia orientada pela Professora Doutora Filipa Alves da Costa,
Professora Auxiliar e coorientada pela Doutora Diana Costa, Mestre

Mestrado Integrado em Ciências Farmacêuticas

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Trabalho Final de Mestrado Integrado em Ciências Farmacêuticas apresentado à Universidade de Lisboa através da Faculdade de Farmácia

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Resumo

Objetivo: Este estudo procurou identificar boas práticas de vacinação que tenham sido implementadas durante a pandemia COVID-19 para a melhoria da cobertura de vacinação em países africanos, e compilar recomendações que possam ser aplicadas a outras iniciativas de vacinação no continente africano, em contexto pós-pandémico.

Metodologia: Para atingir esses objetivos, pesquisou-se em sites de organizações internacionais para contextualizar o tema em questão. Em seguida, foi realizada uma revisão de literatura utilizando o PubMed, com base em palavras-chave predefinidas, "Africa"; "COVID-19"; "Vacinação"; "Estratégias", e critérios de inclusão e exclusão. Os artigos extraídos foram registados e analisados. O critério de inclusão compreendeu artigos cujo acesso integral era possível e publicados nos anos de 2020 a 2023. Os critérios de exclusão englobaram a ausência de referências a países africanos, vacinas ou COVID-19; ou nenhuma referência a boas práticas ou recomendações.

Resultados: Dos 464 artigos inicialmente identificados, 392 foram excluídos: 150 não tinham referências a países africanos, vacinas ou COVID-19, 216 não se concentravam em boas práticas ou recomendações e 26 eram duplicados. Entre os 72 inicialmente selecionados para análise integral, 18 seriam excluídos e 13 artigos adicionais viriam a ser identificados, dos quais 5 foram excluídos. Ao todo, foram analisados integralmente 85 artigos, dos quais 62 foram incluídos neste estudo. De seguida, procedeu-se à sumarização das boas práticas e recomendações referidas nos artigos incluídos.

Conclusão: O estudo destaca boas práticas e recomendações para garantir um acesso equitativo a vacinas em África, considerando lições da pandemia de COVID-19. Os resultados permitem identificar abordagens comunitárias, estratégias de comunicação coesa para enfrentar a hesitação vacinal e práticas que promovam a sustentabilidade operacional, como compartilhamento de dados em tempo real. Além disso, este estudo recomenda o estabelecimento de um modelo global de partilha de riscos para superar a lacuna na disponibilidade de vacinas verificada em alguns países africanos, e reforça a necessidade de serem produzidas orientações internacionais que capitalizem as lições da vacinação durante a pandemia para outras iniciativas de imunização que podem contribuir para o alcance dos objetivos da Agenda de Imunização 2030.

Palavras-chave: África; COVID-19; Recomendações de Vacinação; Acesso a Vacinas

Abstract

Objective: This study aimed to identify vaccination best practices implemented during the COVID-19 pandemic to enhance vaccination coverage in African countries and to compile recommendations derived from these practices to apply to other vaccination initiatives on the African continent in a post-pandemic context.

Method: To achieve these objectives, international organizations websites were consulted to contextualize the subject. Subsequently, a literature review was conducted using PubMed, based on predefined keywords: "Africa," "COVID-19," "Vaccination," "Strategies," and inclusion and exclusion criteria. Extracted articles were recorded and analyzed. The inclusion criterion encompassed articles with possible full access published from 2020 to 2023. Exclusion criteria included the absence of references to African countries, vaccines, or COVID-19, or those with no mention of best practices or recommendations.

Results: From the initially identified 464 articles, 392 were excluded: 150 lacked references to African countries, vaccines, or COVID-19, 216 did not focus on best practices or recommendations, and 26 were duplicates. Among the 72 initially selected for comprehensive analysis, 18 were excluded, and 13 additional articles were identified, of which 5 were excluded. In total, 85 articles were comprehensively analyzed, with 62 included in this study. The best practices and recommendations mentioned in the included articles were then summarized.

Conclusion: The study highlights best practices and recommendations to ensure equitable access to vaccines in Africa, considering lessons from the COVID-19 pandemic. The results help identify community-centric approaches, cohesive communication strategies to address vaccine hesitancy, and practices promoting operational sustainability, such as real-time data sharing. Furthermore, this study advocates for the establishment of a global risk-sharing model to overcome the vaccine availability gap observed in some African countries and emphasizes the need for international guidelines that leverage on vaccination lessons from the pandemic for other immunization initiatives, contributing to achieving the goals of the Immunization Agenda 2030. **Keywords:** Africa; COVID-19; Vaccination Recommendations; Vaccine Access; Vaccination Coverage

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Abbreviations

CDC – Centers for Disease Control and Prevention

CI – Confidence Interval

COVAX – COVID-19 Global Access

DTP-3 – Diphtheria, Tetanus, and Pertussis Vaccine, Third Dose

EMA – European Medicines Agency

IMF – International Monetary Fund

NDVP – National Deployment and Vaccination Plan

PALOP – Países Africanos de Língua Oficial Portuguesa (Portuguese-speaking African countries)

PHEIC – Public Health Emergency of International Concern

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses

SARS-CoV-2 – Severe Acute Respiratory Syndrome Coronavirus 2

TRIPS – Trade-Related Aspects of Intellectual Property Rights

UNICEF – United Nations International Children's Emergency Fund

WHO – World Health Organization

WHO Africa – World Health Organization Regional Office for Africa

Table of Contents:

Figures:

Tables:

1 Contextualization

1.1 The COVID-19 pandemic

The COVID-19 pandemic posed an unprecedented global challenge, profoundly affecting public health worldwide. To combat the virus's impact, the international community mobilized to ensure population protection through vaccination. However, vaccine coverage in Africa was limited due to various barriers.

The coronavirus disease 2019 (COVID-19) is an infectious disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). (1) The first cases of COVID-19 were detected in China in December 2019 (2), and after its global outbreak, WHO declared it a Public Health Emergency of International Concern (PHEIC) on 30th January 2020 (3), starting to characterize COVID-19 as a pandemic on 11 March 2020. (4)

As of 2nd November 2023, there have been 771,679,618 confirmed cases of COVID-19, including 6,977,023 deaths, reported globally to WHO. (5)

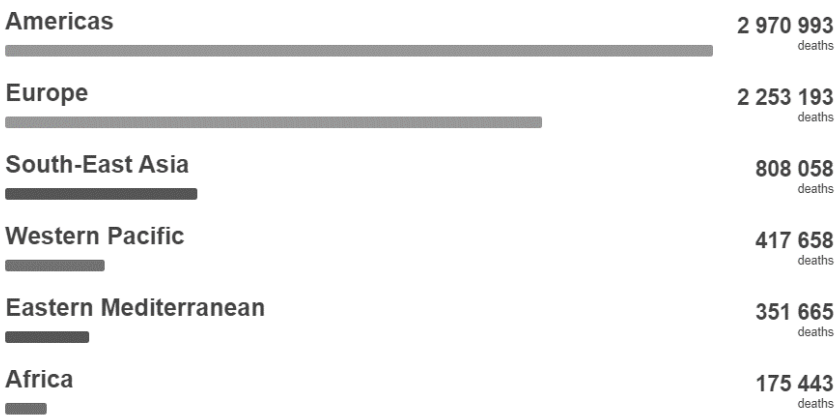

Figure 1 - COVID-19 confirmed deaths across the globe, 2nd November 2023 (5)

The first COVID-19 vaccine to be authorized by a stringent regulatory authority for emergency use in December 2020 was an mRNA-based vaccine. (6) Subsequently, several vaccines were approved and distributed across the globe. As of 22nd October 2023, a total of 13,533,465,652 vaccine doses have been administered, as reported by the WHO. (5)

A study funded by the World Health Organization (WHO) and Gavi. the Vaccine Alliance, estimates that vaccinations against COVID-19 prevented 14.4 (95% CI, 13.7-

15.9) million deaths in 185 countries between 8th December 2020 and 8th December 2021. However, it suggests that an additional 111% (95% CI, 105-118) could have been averted had the coverage targets set by WHO been met by each country. (7)

1.2 Global COVID-19 Vaccination

In May 2021, the Director-General of the WHO urged all Member States to support vaccination of at least 10% of the population of every country by September and at least 30% by the end of the year. (8) During the G20 Global Health Summit 2021, the Managing Director of the International Monetary Fund (IMF) proposed vaccinating 40% of the world's population by the end of 2021 and 60% by mid-2022. (9) In October 2021, the WHO launched the Strategy to Achieve Global COVID-19 Vaccination by mid-2022, aiming to reach 40% of global coverage by the end of 2021 and 70% by mid-2022. (10)

Globally, as of 2nd November 2023, 66.18% of the population is vaccinated, less than the 70% aimed by the WHO. (5)

Furthermore, there are disparities concerning vaccination coverage between regions (Figure 2).

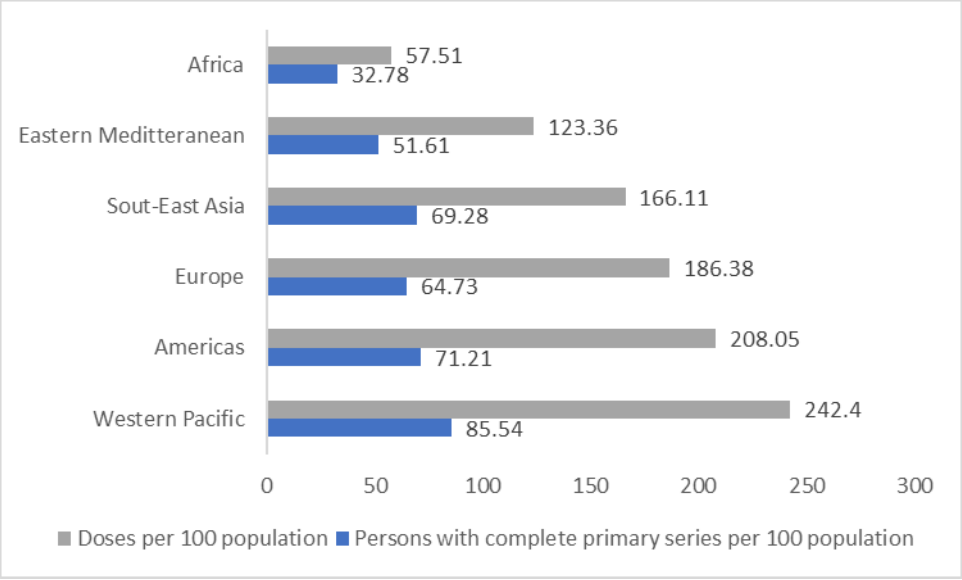

Figure 2 - Regional vaccination coverage against COVID-19, as of 2nd November 2023 (5)

Africa has the lowest vaccination coverage among regions. Within the region, there are variations in the proportion of the population that has received the COVID-19 vaccine. To illustrate this point, vaccination coverage data of the Portuguese-speaking African

countries (Portuguese: Países Africanos de Língua Oficial Portuguesa; PALOP) were collected at the date of 31st October 2023 (Figure 3). None of the countries reached the coverage goal of the WHO.

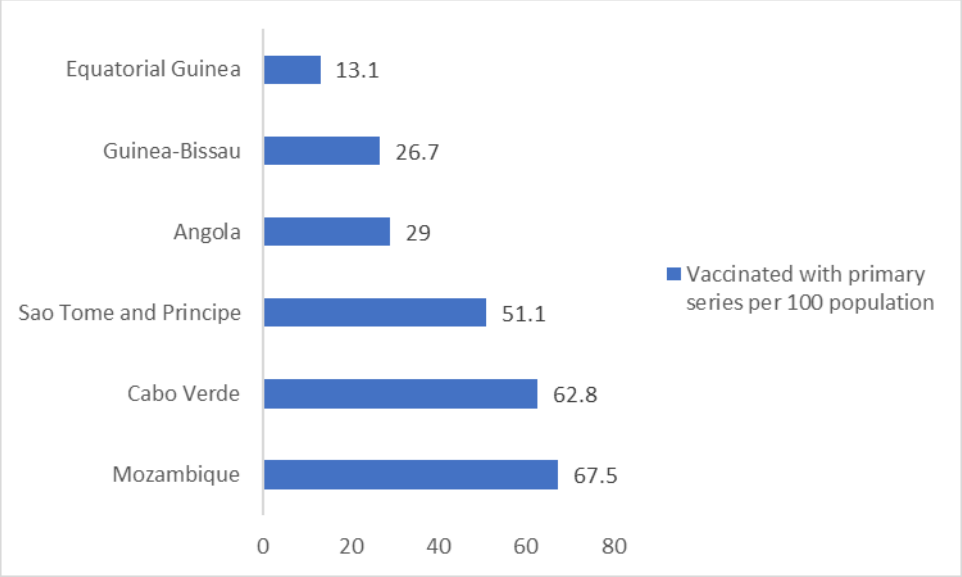

Figure 3 - COVID-19 vaccination coverage of the Portuguese-speaking African countries, 31st October 2023 (11)

1.3 Barriers for vaccination

The low vaccination coverage in Africa can be attributed to various barriers. Table 2 provides context for those identified for the purposes of this study. (12–14)

Table 1 - Barriers for Vaccination on Africa

Barrier for vaccination	Explanation
Lack of vaccine supply	This is the main issue. African countries have limited capacity to manufacture COVID-19 vaccines
Supply by donations	Supply is unpredictable and frequently with short-dated products.
Intellectual property	The lack of waiving of intellectual property created obstacles for low-income countries manufacturing their own vaccines, leading to multiple

	vaccines, each requiring separate paths to licensure.
Local manufacturing	The absence of technology transfer and inadequate created obstacles to local manufacturing capacities.
Storage or distribution requirements and limited shelf life of COVID-19 vaccines	African countries have reported difficulties to in establishing a cold chain, essential for some of the vaccines, and monitoring the vaccine distributions. Other challenges include frequent power outages or inadequate road networks. The limited shelf life of COVID-19 vaccines creates struggles relating to its distribution and storage and frequently results on large numbers of vaccines being destroyed.
Inadequate financial resources	Resources are needed for the vaccine, distribution and delivery of vaccines, as well as communication and training strategies. Lack of domestic and external funding programs focused on vaccine products has overlooked other pertinent costs.
Vaccine confidence	The lack of demand is influenced by several factors, including concerns about the vaccine, low perception of risk, mistrust in the system at a global, national. Accessibility barriers contribute to this issue.
Hard-to-reach populations	Vulnerable populations, such as those living in on war-torn regions, which are frequent on the African continent, or

	remote populations, often face exclusion from immunization initiatives.
Gradual implementation	Many countries have reported delays in vaccine rollouts. This may result from diverse factors, such as lack of vaccine supply, lack of trained professionals, hesitancy among the population, inadequate planning, insufficient funds, or incomplete reporting.
Using different vaccines	While using different vaccines expands coverage, challenges arise in defining distribution, handling differing logistics and storage requirements, and training professionals for administration.
Disruptions to essential health services	The reallocation of staff to other COVID-19 relief efforts and population's fear of contracting COVID-19 in health facilities resulted on major disruptions and delayed other immunization drives.

1.4 Universal Vaccination Coverage

At the 2012 World Health Assembly, all Member States endorsed the Global Vaccine Action Plan, with the goal of achieving 90% national vaccination coverage by 2020. Subsequently, the African Regional Strategic Plan for Immunization established targets for the eradication of polio and the elimination of measles, rubella, and maternal and neonatal tetanus by 2020.(15,16) These objectives endorsed by Heads of State of the African Union on the historical 2016 Addis Ababa Declaration on Immunization and the subsequential Ministerial Conference on Immunization in Africa.(17) Despite this global and regional commitment to vaccination coverage, the COVID-19 pandemic led to major disruptions on health services. Figure 4 illustrates the complex relations between COVID-19 related measures and vaccination performance. This visual

representation underscores the challenges posed by the pandemic to ongoing vaccination efforts and the broader implications on public health.

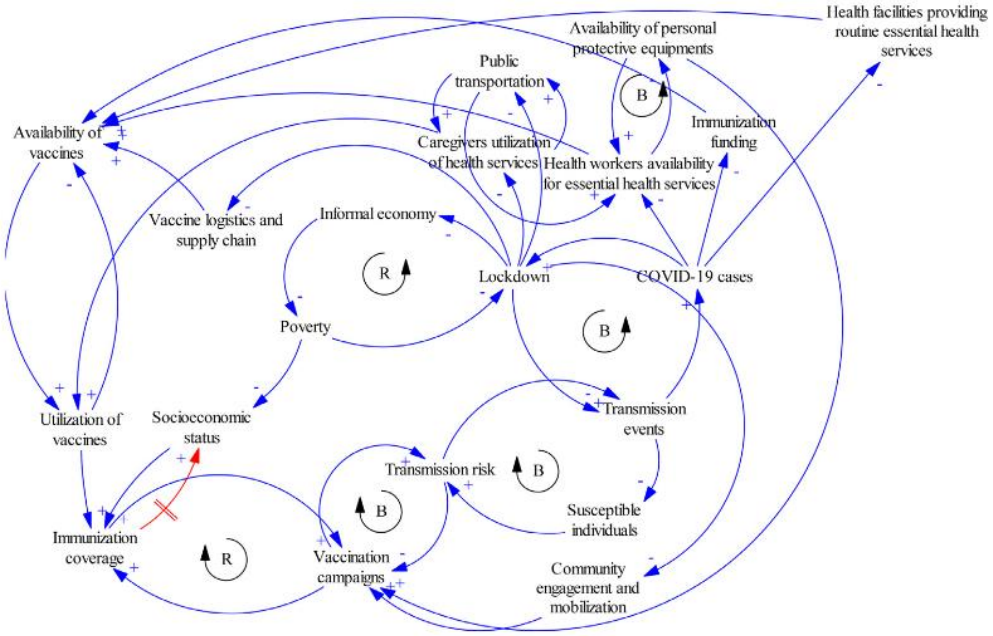

Figure 4 - Relation between COVID-19 related measures and vaccination performance (18)

In 2021, the world saw the worst decline in routine vaccination in 30 years, resulting in outbreaks of some vaccine preventable diseases: 18 African countries reported a measles outbreak in 2022 and new polio cases have re-emerged in African countries that had not reported any case of the virus in decades and crossed borders to the United Kingdom, United States and Israel. (19) As of 2021, 9 African countries accounted for 43% of zero-dose children recorded in 20 priority countries. Additionally, as of 2022, while all global regions, except Africa, experienced a recovery to below 2019 coverage levels of the vaccine protecting against diphtheria, tetanus, and pertussis (DTP-3), the African Region continued to see a decline in measles vaccine coverage as of 2022. (20)

The new Immunization Agenda 2030, a global strategic framework, aims to address these challenges during this decade and save over 50 million lives, preserving hard-won gains on immunization and fighting the disruptions caused by COVID-19. (21)

2 Objectives

This study aimed to:

1) Identify good vaccination practices for improvement of vaccination coverage in African countries during the COVID-19 pandemic.

2) Compile recommendations that can be transposed to other lifelong vaccination initiatives in African countries.

3 Methods

To adress the objectives of the present study, a literature review was performed. Table 1 sumarises the relevant elements that guided this review. Website research was used mainly for contextualization purposes, such as to identify vaccination barriers, but a limited number of publications were included, considering compliance to criteria for inclusion.

Table 2 – Elements of the searched literature.

Database	Terminology and Boolean Operators	Criteria of inclusion	Criteria of exclusion	Language
• PubMed - Acessed August 2023 (https://pubmed.ncbi.nlm.nih.gov)	Africa AND COVID-19 AND Vaccination AND Strategies	Full articles, from the years 2020-2023.	• No references to african countries, vaccines or COVID-19; • Without focus on good practices or recommendations; • Duplicates.	English
Websites				
• WHO Africa – Acessed April 2023 (https://www.afro.who.int/) • Africa CDC – Acessed April 2023 (https://africacdc.org) • African Union – Acessed May 2023 (https://au.int)	A search was conducted on websites of international organizations to contextualize the subject. All titles of publications between 2021-2023 were assessed. When deemed relevant to contextualization of the subject, selected publications were fully analised. A limited number of articles complied with criteria of inclusion and exclusion and were included on the present study.			

The articles selected for this study were then assessed using the SALSA (search, appraisal, synthesis, and analysis, not including a quality assessment) method (22) and

their respective references, the countries where they occur or which they refer to in their writing, their typology or study design and the main findings were recorded. In addition, the articles selected had to be categorised. It was decided to use the categories recommended by the WHO for the structure of a national deployment and vaccination plan (NDVP) for COVID-19 vaccines (23), and then implementation outcomes were assigned to each article (Table 3), based on the specific dimensions of access describing the relation between patients and the health care system, and considering the practices described. (24) An additional outcome, sustainability, was theorised, to address the penetration and innovation regarding procedures that strengthen the efficiency and quality of vaccination programmes, based on the "Penetration" and "Sustainability" implementation outcomes proposed by Proctor et al. (25). Supplement 1 is a comprehensive overview of all the compiled and categorised content resulting from the evaluation of the articles included in the study. The results summarise the data obtained from the operationalised literature review.

Table 3 - Categorisation of articles included, considering NDVP categories and implementation outcomes

Topics mentioned on articles	National deployment and vaccination plan (NDVP) category	Implementation Outcomes
• Vaccination strategies and logistics	Vaccination delivery strategies	Accessibility
• Demand planning • Drivers of vaccine acceptance and uptake • Integrated demand approach	Vaccine acceptance and uptake	Acceptability
• Impact and effectiveness • Lessons learned	Evaluation of vaccine rollout	Sustainability
• Human resources requirements • Trainings • Supervision	Human resource management and training	

• Data needs and monitoring objectives • Indicators • Monitoring systems	Immunization monitoring systems	
• Supranational entities • Coordination mechanisms • Technical advisory groups • Chain of reporting • Simulation exercises	Planning, coordination and simulation	
• Preparation • Logistics and cold chain capacity • System functionality • Vaccine tracking • Reverse logistics • Health care waste	Supply chain and health care waste	Sustainability
• Estimate financial resources • Alignment within available resources • Funding options	Costing and Funding	
• Procedures	Regulatory Preparedness	Availability
• Allocation of vaccines • Identification of target populations • Size of target populations • Equity in distribution • Digital data	Target populations	

4 Results

A total of 62 articles were included. Figure 5 contain an overview of the literature review process regarding the identification of good practices and recommendations.

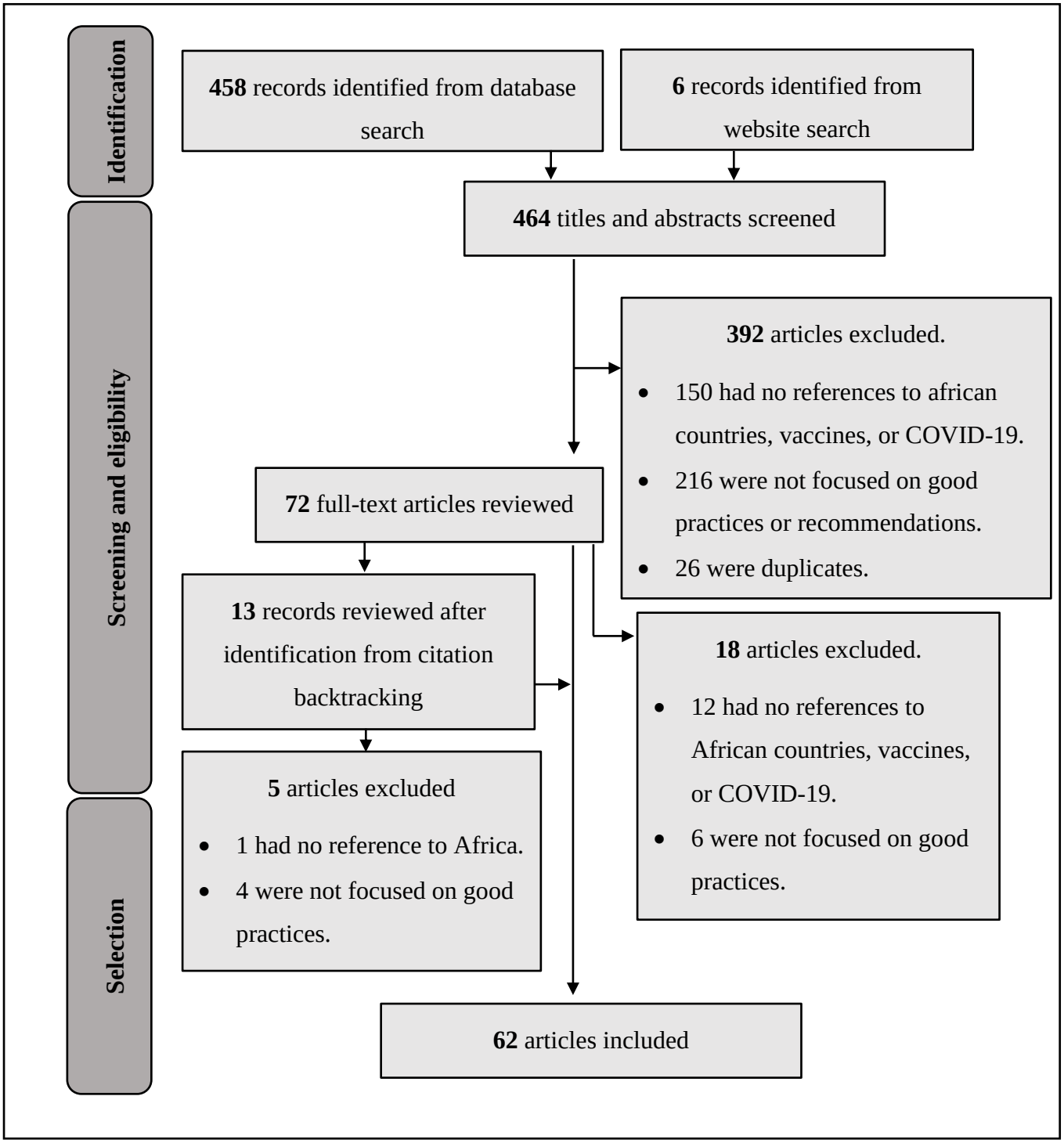

Figure 5 - Overview of the literature review

Of the 464 articles initially identified, a total of 85 were reviewed (72 initially and an additional 13 articles identified in a later phase through bibliography analysis of articles already included), with 62 being included in the study based on the elements mentioned on Table 1 and to the procedure described on Figure 5. A limited number of articles, cited by the initially selected articles, were reviewed when considered relevant for this study and included after validation of compliance with criteria of inclusion and exclusion. Figure 6 represents the number of articles categorised in the present study for each national deployment and vaccination plan (NDVP) category. Some articles were categorised on more than one NDVP category.

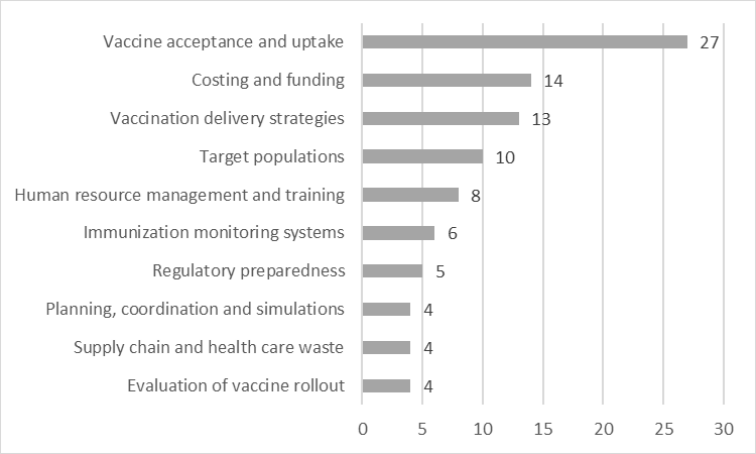

Figure 6 - Number of articles included per NDVP category

Figure 7 represents the number of articles categorised in the present study for each access outcome which was considered. Some articles were indexed on more than one implementation outcome.

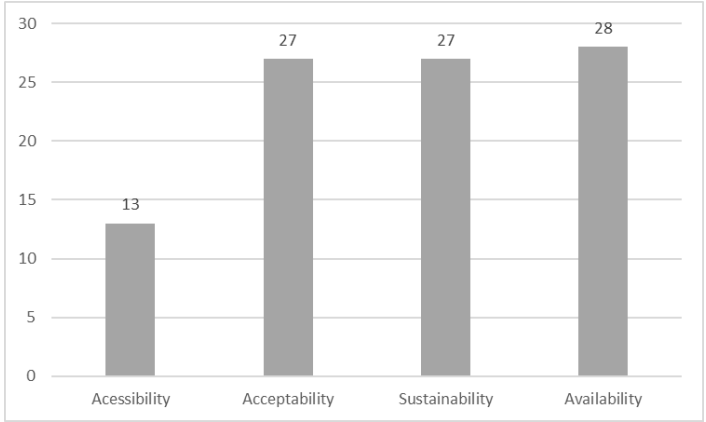

Figure 7 - Number of articles included per access outcome

4.1 Accessibility

Table 4 summarizes the results of the present study concerning acceptability.

Table 4 - Accessibility Results

Access Outcome	*NDVP*	*Results*	*Examples*
Accessibility	Vaccination delivery strategies	Immunization should be viewed as an entry point for Primary Health Care (PHC) services (26–28) Vaccination was integrated on Medical Visits (36) Outdoor and drive-through vaccination clinics were set up (36) Mobile and outreach vaccination teams were deployed (26,31–33) Military involvement in conflict-affected zones was reported (30) Mass vaccination campaigns, integrated campaigns and events-based vaccination was highlighted (35)	• Integrated polio-COVID-19 in Central African Republic.(27) • Door-to-door vaccination in Malawi.(29) • Military involvement in vaccination program in Nigeria.(30) • Mobile medical teams were deployed in South Sudan.(31) • Establishing vaccination hubs in Angola.(32) • Integration of vaccination services in Liberia.(28) • Utilization of mobile health teams in South Africa.(33) • Deployment of medical boats in Ghana.(34) • Nationwide mass vaccination efforts in Tanzania, with temporarily sites, events-based vaccinations and integration of existing

			delivery infrastructures.(35)

4.2 Acceptability

Table 5 summarizes the results of the present study concerning acceptability.

Table 5 - Acceptability Results

Access Outcome	*NDVP*	*Results*	*Examples*
Acceptability	Vaccine acceptance and uptake	It is crucial to mitigate misinformation regarding vaccination (37,38) Studies can be conducted to identify variables that influences public perception regarding vaccination (32,43–45) Surveys can monitor shifts in public perception and adjustment of social mobilization goals (26,41,46,47) Community engagement strategies are critical (27,35,40,42,48–52) Mandatory vaccination can be considered, per instance, for health workers, but there are ethic concerns (48) Healthcare workers play an important role in modeling	• Social mobilisers were deployed in Angola.(32) • A survey identified institutional trust as an important driver of vaccine acceptance in Mozambique.(39) • Community collaborations were relevant in Sierra Leone.(40) • United Nations International Children's Emergency Fund (UNICEF) sponsored human-centered design initiatives allowed for community-informed strategies in Zambia and Ghana. (41) • Evidence-based communication was delivered by trusted

		public behavior regarding vaccination (42–44) Public political support reflets on acceptability (53,54) Role models, community and opinion leaders, media, and religious leaders are important to improve acceptability (42,55) Institutional trust reflects on vaccine acceptability (39)	persons such as healthcare workers and religious leaders in Nigeria.(42) • A model was developed on Guinea to study the behaviors of health care workers, comparing them to those of the general population.(43) • Catch-up programs were relevant on South Africa.(36)

4.3 Sustainability

Table 6 summarizes the results of the present study concerning sustainability.

Table 6 - Sustainability Results

Access Outcome	*NDVP*	*Results*	*Examples*
Sustainability	Evaluation of vaccine rollout	Implementation science with proctor implementation outcomes or causal loop diagrams can be relevant to guide planning and access the success of vaccination programs (18,56) Quality assurance surveys can address evolution of the vaccine rollout (47)	• UNICEF installed solar-powered fridges to store vaccines in different countries. (57) • In Kenya and South Africa, governments invested on innovative or online integrated portals for instant data sharing which allowed policy

	Information systems and integrated data management are required to guide immunization tailoring (38,58,64)	communication and tracing of COVID-19 patients, organizing the population for the vaccine uptake or further actions.(58) • In Ghana, development of the NDVP was based on lessons learned during other immunization campaigns.(59) • Proper training and equipment of health care workers, task shifting, and innovative technology enhanced coverage in Central African Republic.(27) • In Nigeria, most pharmacists would accept to vaccinate.(60) • In Angola, a pre-registration system was used.(32) • In Mozambique, an optimization tool was created for routing and scheduling distribution of vaccines.(61) • Simulation exercises in advance, provision of equipment and training to
<u>Human resource management and training</u>	Public-private partnerships may have enhanced coverage (54)	
	Community pharmacists may be engaged on vaccination efforts (60,65)	
	Training of vaccination teams is paramount (34,63,66)	
	Task shifting health workers can be a management strategy (27)	
	It's relevant to assess occupational drivers for vaccine uptake (67)	
<u>Immunization monitoring systems</u>	Integrated data tools and innovative technology is a priority for vaccination initiatives, with registry, catch-up and monitoring features (58,66)	
	Instant data sharing is relevant to monitor transportation and delivery of vaccines and tracing of COVID-19 patients (58)	

	Planning, coordination and simulation	Proper response coordination among all pertinent stakeholders is a priority (66)	vaccination teams, pre-existing infrastructure and experience, use of international guidelines and broad partnerships enabled a robust vaccination program in Mauritius, Rwanda, Sierra Leone, and Mozambique.(40,62,63) • Reference to a distribution solution that preserves vaccines at very low temperatures without energy.(57)
		Simulation exercises should be performed in advance of critic situations (62)	
		Building on existing experience and infrastructure from other diseases may allow for efficient planning (62)	
		Multisectoral synergy can accelerate vaccine adoption (59)	
		It's recommended to use supranational evidence-based guidelines, such as those concerning the WHO Essential Program on Immunization (62,63)	
		Overbooking appointments is appointed as a good practice (68)	
	Supply chain and health care waste	It's relevant to consider pre-existing refrigeration infrastructure when choosing vaccines for supply (54)	
		Regional frameworks for allocation of vaccines may contribute to a fairer supply chain (57)	

		Maximizing the number of doses being extracted from the vial, and proper surplus donations and reallocations can address vaccine wastage (68)	

4.4 Availability

Table 7 summarizes the results of the present study concerning availability. (12,27,35,36,38,47,49,51,54,57,69–80)

Table 7 - Availability Results

Access Outcome	*NDVP*	*Results*	*Examples*
Availability	Costing and Funding	Supranational entities play relevant roles addressing lack of funding and vaccine affordability.(12,49,57,77,79,81)	• The COVID-19 Global Access (COVAX) coalition, the Coalition for Epidemic Preparedness Innovation, the WHO, and other supranational entities provided donations for low and medium-income countries, concerning COVID-19 vaccines. (77,79)
		Regional procurement processes may address equity issues.(54)	
		Estimating cost drivers of COVID-19 allowed for budgeting of vaccine delivery.(82)	
		Funding may be achieved through assessment-based proposals.(47)	• In Kenya, an activity-based costing analysis was performed to inform on cost drivers
		Mapping external funding opportunities can help identify sources of resources. (80)	

	Regulatory Preparedness	Capacity building and technology transfer is relevant to ensure local manufactory capacities (57,75,77)	of the COVID-19 delivery strategy. (82) • The WHO Ministerial Conference to COVID-19 diagnostics and therapeutics adopted a decision regarding the Trade-Related Aspects of Intellectual Property Rights (TRIPS), wavering the effect of patents on vaccine products.(79,82) • The African Medicines Regulatory Harmonization Initiative aims to establish an effective regulatory framework to fluidise the introduction of vaccines in African countries. (77) • The current revision of the International Health Regulations is addressing global solidarity in the wake of COVID-19.(79)
		Waiver of intellectual property enables production of local vaccines (77,79)	
		Supranational prioritization of local producers for financial and technical support early on, while supporting rapid scale-up of new technologies (75)	
	Target populations	Mathematical models that use parameters based on virus characteristics, epidemiological and demographic data, hospitalizations, and vaccination numbers, helps defining priority populations (69,70,72,73)	
		Targeted approaches may address issues such as lack of resources, while ensuring coverage to those at higher risk. (51,76)	
		Artificial intelligence machine learning techniques can enhance analysis of multiple data sources to inform public health decision making (71)	

5 Discussion

The importance of vaccination as a public health intervention, particularly in the face of a global pandemic, is evident. However, ensuring equitable access and coverage across the African continent has been a complex endeavour, influenced by a multitude of challenges.

This study has investigated into four access outcomes that shape the landscape of vaccination. By examining accessibility, acceptability, sustainability, and availability, while considering the challenges identified, it was possible to determine suitable lessons which could be applied to other immunisation initiatives.

5.1 Accessibility

The COVID-19 pandemic has prompted creative thinking in vaccination platform design, particularly in outreach mass vaccination strategies. Examples show a shift in vaccination procedures where health professionals go to communities, promoting accessibility, acceptability, and fostering a relationship of trust. Therefore, it is impossible to neglect the planning of community communication strategies when structuring a vaccine delivery strategy.

In terms of accessibility (Table 4), namely vaccine delivery strategies, the literature analyzed (25-36) underscores the value of approaches that promote the capitalization of primary health care, integrating vaccination into other health services, valuing the proximity that routine care professionals have with the population. On the other hand, there are various strategies, such as mobile teams or drive-through clinics, for reaching hard-to-reach or vulnerable populations who, per instance, live on war-torn regions. Relevant challenges relate to regions without infrastructure, or which are devastated by war, and military involvement can be a potential response to safeguard the safety of those involved in the vaccination process.

Unfortunately, there is limited literature addressing how to respond to the logistical challenges involved in each of the vaccine delivery mechanisms, particularly on the African continent, which is why accessibility should be an area of focus when it comes to producing scientific evidence.

5.2 Acceptability

The lessons derived from **accessibility** lessons underscores the transformative potential of innovative vaccination platform designs. Shifting the paradigm towards community-centric approaches, where health professionals reach out to citizens, accessibility, and acceptability, can be simultaneously elevated. Planning community communication strategies is deemed indispensable, emphasizing the need to value each person individually as the central focus of the health system.

Vaccine hesitancy is one of the main barriers to vaccination on the African continent (12-14), due to the low-risk perception of COVID-19 and, on the other hand, concerns about vaccine safety and effectiveness. There is a lot of literature on vaccine acceptability (Table 5) and hesitancy (25–29,33,37–57), particularly studies that characterize population motivations and barriers to immunization uptake. Assessing behavior drivers and motivations for vaccination is a strategy that can inform risk communication mechanisms, making them tailored to each national and local reality. On the other hand, this data needs to be updated over time, as public perceptions change. However, it was identified little literature on the practical applicability of the results of population studies on confidence in vaccination.

In the context of community communication strategies, the studies identified point to the importance of health professionals and political players and other opinion leaders. In this sense, these social mobilizers are target audiences to intervene in raising awareness of the importance of vaccination, insofar as they can indirectly intervene in the general population.

In addition, it is crucial that there is a cohesive message between the various government and health institutions. Risk communication strategies must be prepared in advance, preventing any communication lapses that could destabilize the results obtained. All these processes can involve multidisciplinary teams in addition to the usual health professionals, which can include psychologists, designers, journalists, and sociologists.

5.3 Sustainability

Regarding the **sustainability** of vaccination programs in times of pandemic (Table 6), proper planning, based on recommendations from supranational entities validated by evidence and technical knowledge and on previous experience with other diseases, can safeguard the programs' effectiveness and their implementation. On the other hand, it is essential to ensure that the programmatic lines consider the coordination of all the players involved in promoting vaccination, and that they make the most of multisectoral synergies.

Some of the main barriers to vaccination in Africa are related to the distribution and storage of vaccines. (12-14) The literature identifies technological solutions that optimize processes related to these barriers, reducing vaccine waste. In fact, it is along these technological advancements driven by COVID-19 has made it possible to greatly boost global immunization efforts: the emergence of instant-data-sharing programs that make it possible to monitor the progress of immunization in real time, tracing people, catching them up and parameterizing vaccine stocks, revolutionized the process of managing vaccination campaigns. It is crucial to capitalize on this technological evolution in other immunization initiatives. (32,38,57,58,61,64,66)

Finally, it is important to mention the human resources management processes, which must reconcile vaccination with other health priorities. Ensuring their training and that they have the right equipment for vaccination efforts must be a priority. There is literature describing efforts to train human resources and strengthen the vaccination infrastructure, even with few resources. (27,34,54,60,63,65,66,67) It should also be considered that human resources are the mechanisms that implement the other access outcomes, so raising their awareness of vaccination is a fundamental step in shaping population acceptability, as mentioned above. Understanding the occupational drivers for vaccination and their perception of risk must is needed to ensure optimal vaccine adherence on the part of health professionals, which will have repercussions for the rest of the population.

5.4 Availability

Certainly, the main barrier to vaccination in Africa has undoubtedly been the lack of vaccines (12-14). This may be attributed to a confluence of factors, including the vaccine market monopoly by other countries, financial constraints, limited local

manufacturing capacity, and intellectual challenges. In this context, various supranational initiatives have allowed the supply of vaccine doses to low-income countries. It is essential for each country to plan considering the available external financing opportunities but also to allocate domestic investments in other needs related to the implementation of immunization initiatives. Rigorous estimation of the diverse cost drivers associated with vaccination can enhance budget planning on this matter (Table 7).

On a broader global scale, there is an urgent need for investment in the debate surrounding international solidarity commitments and realize that public health issues should be addressed as a model of global risk and benefit sharing, where the protection of no one is ensured until everyone is protected. It is regrettable that there are countries where most of the population has not yet received a second dose of the primary COVID-19 vaccination series, while in others there is a possibility for receiving multiple boosters (Figures 2 and 3). These are economic and political issues that gain strength when there is regional cohesion in their approach, which can be achieved through frameworks to promote the equitable distribution of vaccine doses and regulatory harmonization for vaccine introductions. However, in scenarios of vaccine scarcity, it is essential to clearly define which high-risk populations are in greater need of vaccines, ensuring judicious allocation and ensure that there is no vaccine wastage. Leveraging scientific evidence, supranational recommendations, and applying mathematical models and artificial intelligence can contribute to achieving these goals. (12,26,27,29,40,41,44,46,49,56,58,71–81)

6 Conclusion

This study identified a set of good practices and recommendations for the accessibility, availability, acceptability, and sustainability of some African vaccination programmes during the COVID-19 pandemic, which can be transposed to other vaccination initiatives.

In terms of **accessibility**, some good practices have been identified as the integration of vaccination initiatives, door-to-door vaccination, military involvement in conflict areas, mobile medical teams, vaccination hubs, medical boats, and mass vaccination campaigns. The integration of vaccination into primary healthcare is particularly emphasized, ensuring that proximity mechanisms are established, and the population has easy access to vaccination, even if they are in remote or hard-to-reach areas.

As far as **acceptability** is concerned, the use of social mobilisers, vaccine confidence studies, fostering community collaborations, implementing human-centred design initiatives which allowed community-informed strategies, delivering evidence-based communication through social trusted figures such as health professionals, opinion leaders and religious personalities, and instituting individualised follow-up programmes stand out. In this sense, mitigating misinformation must be a priority, using multidisciplinary health teams, community engagement strategies, social mobilisers, and tools to assess the drivers of motivation and address vaccine hesitancy.

In the context of **sustainability**, the use of technological solutions for maintenance of vaccines such as solar energy or electricity-independent systems has been identified. There has also been an investment in innovative or integrated portals for instant data sharing, enabling policy communication and tracing, pre-registration of COVID-19 patients, and organizing the population for vaccine uptake or further actions. Planning based on lessons from the past, simulation exercises, adherence to international guidelines, and adequate training for vaccination teams, are also highlighted. Among the compiled recommendations, the need for multisectoral synergy stands out.

Finally, regarding vaccine **availability**, the relevance of supranational coalitions for donations to low and medium-income countries, concerning COVID-19 vaccines, is emphasized. This study highlights conducting analyses to identify cost drivers in vaccination, the decision to waive the effect of patents on vaccine products,

mobilization to standardize vaccine introduction in the African continent, and the current review of the International Health Regulations to address global solidarity in the wake of COVID-19. Among the recommendations, there is an emphasis on the need to enhance local manufacturing capacity, adopt targeted approaches for populations with the greatest benefit in vaccine uptake, and utilize artificial intelligence techniques to map target populations for vaccination initiatives.

In summary, this study underscores the need for ongoing efforts to improve vaccine coverage in African countries. It is crucial to build on the lessons learned during the COVID-19 pandemic and apply them to other immunization initiatives. In the case of African countries, it will be important to develop a guidance document that includes the lessons learned in the pandemic as a way of improving vaccination programmes, to be made available by organisations such as the WHO.

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Supplementary material

S1. Articles included in the literature review

Reference	*Country*	*Study Design*	*Main Findings*	*NDVP Category*	*Outcome*
(69)	Senegal	Mathematical model	A model which uses parameters based on SARS-CoV-2 virus, information on diverse types of NPIs, epidemiological and demographic data, hospitalisations, and vaccination numbers, suggests cost-effective vaccine prioritization and distribution strategies.	Target populations	Availability
(37)	South Africa	Narrative literature review	Describes strategies to mitigate misinformation regarding vaccination.	Vaccine acceptance and uptake	Acceptability
(44)	Libya	Cross-sectional study	Determines the association between acceptance of the vaccine and study variables among the general population and healthcare workers.	Vaccine acceptance and uptake	Acceptability
(70)	South Africa	Mathematical model	Age-specific compartment model to assess vaccine allocation strategy.	Target populations	Availability
(71)	South Africa	Report	Artificial Intelligence machine learning techniques can enhance analysis of multiple data sources to inform clinical public health decision-making.	Target populations	Availability
(46)	Africa	Commentary	Commentary on challenges and recommendations concerning third wave of COVID-19 in Africa. It focuses on public awareness about vaccines.	Vaccine acceptance and uptake	Acceptability
(38)	Africa and Middle East	Narrative literature review	Covers COVID-19 epidemiology, vaccination strategies and lessons within Africa and the Middle East.	Costing and funding	Availability
				Immunization monitoring systems	Sustainability
				Vaccine acceptance and uptake	Acceptability
(79)	Africa	Commentary	Addresses intraregional inequality, health-care systems strengthening	Vaccine acceptance and uptake	Acceptability

			and lessons from community engagement regarding malaria vaccination during the COVID-19 pandemic.	Costing and funding	Availability
(12)	Africa	Narrative literature review	Potential solutions on key issues of vaccine equity and justice.	Costing and funding	Availability
(72)	Madagascar	Mathematical model	Mathematical model of transmission dynamics which simulates vaccination allocation strategies.	Target populations	Availability
(50)	Africa	Commentary	Addresses the impact of the epidemic on children immunization and suggests proper strengthening of service delivery systems and focus on rebuilding trust through community engagement.	Vaccination delivery strategies	Accessibility
				Vaccine acceptance and uptake	Acceptability
(73)	West Africa	Mathematical model	Projection of the trajectory and speed of vaccine rollout needed to achieve a coverage rate of at least 60% of the total population.	Target populations	Availability
(74)	Africa	Review	Discusses the necessity of proper establishment of localized vaccine production facilities on Africa, which will increase vaccine availability.	Costing and funding	Availability
(36)	Global, South Africa	Qualitative	Reports on strategies for influenza vaccination during the COVID-19 pandemic. References to outdoor and drive through vaccination clinics, combining vaccination with medical visits, alternate delivery models, separate vaccination sessions for medically vulnerable people, communication strategies and developing registry and catch-up programmes, mandatory vaccination for health care workers and use of personal protective equipment.	Target populations	Availability
				Vaccination delivery strategies	Accessibility
				Immunization monitoring systems	Sustainability
				Vaccine acceptance and uptake	Acceptability
(43)	Guinea	Cross-sectional Study	Model to study the behaviours of health care workers and general population regarding vaccination, suggesting	Vaccine acceptance and uptake	Acceptability

			they can be potential barriers to vaccine acceptance.		
(54)	Zimbabwe	Narrative literature review	It explores the strengths, weaknesses, opportunities and achievements of COVID-19 vaccination, highlighting political will, strong international relations, public awareness, pre-existing refrigeration infrastructure and effective vaccine procurement strategies, while referring public-private partnerships, education of health care workers, platforms creating vaccine awareness and mobile vaccination centres.	Vaccine acceptance and uptake	Acceptability
				Costing and funding	Availability
				Supply chain and health care waste	Sustainability
				Human resource management and training	Sustainability
				Vaccination delivery strategies	Accessibility
(53)	South Africa	Commentary	Public political support for vaccination may have led to an increase in willingness to accept COVID-19 vaccines.	Vaccine acceptance and uptake	Acceptability
(57)	Africa	Commentary	Commentary piece on challenges and recommendations concerning equity of access to COVID-19 vaccines. It focuses on the necessity of a framework for fair allocation of vaccines, public awareness about vaccines, capacity building and strengthening of vaccination infrastructure. There is a reference to solar panel powered fridges and Artek, a distribution solution that preserves vaccines at very low temperatures without energy.	Costing and funding	Availability
				Regulatory preparedness	Availability
				Supply chain and health care waste	Sustainability
(75)	Global	Commentary	It focus on low and middle income countries lessons regarding vaccine production, namely on capacity building for regulatory science, prioritization of local producers for financial and technical support early on and	Regulatory preparedness	Availability
				Costing and funding	Availability

			production of vaccines based on existing capabilities, while supporting rapid scale-up of new technologies. There are references to a portfolio approach using multiple different vaccine technologies and to strategic partnerships between high income countries and low to meddle income countries regarding capacity building and technology/intellectual transfer.		
(51)	Africa	Commentary	Reference to communities' integration on vaccination strategies and targeted approaches to focal transmission.	Target populations	Availability
				Vaccine acceptance and uptake	Acceptability
(55)	Africa	Narrative literature review	Human rights activists, ethicists, politicians, and healthcare workers should work together to enhance vaccine acceptance.	Vaccine acceptance and uptake	Acceptability
(26)	Africa	Commentary	Vaccination strategies should be guided by four principles: Scale-up, Transition, Consolidation and Communication. References to mobile and outreach teams and the need for a community-centred approach, integration of vaccination services into routine care, robust data management and communication by role models and community leaders.	Vaccination delivery strategies	Accessibility
				Immunization monitoring systems	Sustainability
				Vaccine acceptance and uptake	Acceptability
(35)	Tanzania	Report	Reference to health facilities, mobile units, temporarily fixed sites, and events-based vaccinations in communities. Focus on integrating existing HIV, tuberculosis, and other service delivery infrastructures on mass vaccinations nationwide, and strategic partnerships with international stakeholders.	Target populations	Availability
				Vaccination delivery strategies	Acessibility
				Vaccine acceptance and uptake	Acceptability

(58)	South Africa, Kenya	Qualitative	It focus on innovation regarding integrated databases for instant data sharing to monitor transportation systems and the delivery of vaccines and tracing of COVID-19 patients.	Immunization monitoring systems	Sustainability
(52)	Sub-Saharan Africa	Narrative literature review	Community vaccination integrated with community-sensitive strategies with appropriate considerations for socioeconomic and cultural factors can enhance vaccine acceptance.	Vaccine acceptance and uptake	Acceptability
(65)	Africa	Narrative literature review	Community pharmacists can be involved in vaccination programmes.	Human resource management and training	Sustainability
(83)	Cameroon	Cross-sectional study	References to deployment of social mobilizers, increasement of mobile teams and vaccination fixed sites, intensive vaccination campaigns and the necessity of an early risk communication strategy.	Target populations	Availability
(56)	Global	Narrative literature review	Proctor implementation outcomes can be relevant for examining the success of COVID-19 vaccination programs globally.	Evaluation of vaccine rollout	Sustainability
(81)	Africa	Narrative literature review	It contains policy recommendations concerning vaccine affordability through regional and international partnerships.	Costing and funding	Availability
(48)	South Africa	Qualitative	Communication strategies and engagement with stakeholders could influence perceived acceptance barriers instead of mandatory vaccination policy to university students.	Vaccine acceptance and uptake	Acceptability
(47)	Ghana	Report	Development of the NDVP was based on lessons learned during other immunization campaigns. References to funding achievement through assessment-based proposals, media	Evaluation of vaccine rollout	Sustainability
				Costing and funding	Availability
				Vaccine acceptance and uptake	Acceptability

			scanning to understand acceptance drivers, and deployment of community leaders and Commentary leaders to address hesitance. Quality assurance sampling surveys identified hard to reach communities.		
(18)	Africa	Narrative literature review	Implementation science and causal loop diagram can guide immunization tailoring.	Evaluation of vaccine rollout	Sustainability
(76)	Africa	Commentary	It recommends targeting of priority populations rather than general population, to overcome the low coverage. Reference to necessity of redefinition of research priorities concerning Africa immunity.	Target populations	Availability
(66)	Africa, South America	Mixed-methods study	References of the need of prioritising community engagement, training vaccination teams; enhance proper response coordination and vaccination monitoring functions and exploring opportunities for health service integration.	Planning, coordination and simulation exercises	Sustainability
				Vaccine acceptance and uptake	Acceptability
				Human resource management and training	Sustainability
(27)	Central African Republic	Report	Integrated polio-COVID 19 campaign increased coverage. References to integrated data tools, innovative technology and community engagement through task shifting to train and equip existing health workers to deliver vaccination.	Vaccination delivery strategies	Accessibility
				Vaccine acceptance and uptake	Acceptability
				Immunization monitoring systems	Sustainability
				Human resource management and training	Sustainability
(77)	Africa	Narrative literature review	It recommends enlargement of the COVAX program, waiver of intellectual property rights to allow manufacturing on low income countries and improving production capacity on Africa. References to scaling up mass vaccination campaigns with	Regulatory preparedness	Availability
				Costing and funding	Availability

			international stakeholders across the continent and enhancing health systems robustness.		
(64)	Africa	Commentary	Adequate information systems and data management are required to proper guide immunization tailoring and recommends priorization of education strategies.	Evaluation of vaccine rollout	Sustainability
(29))	Malawi	Cross-sectional study	Door-to-door vaccination improved vaccination coverage.	Vaccination delivery strategies	Accessibility
(42)	Nigeria	Case-control study	Evidence-based community education should be delivered by trusted persons such as healthcare workers and religious leaders.	Vaccine acceptance and uptake	Acceptability
(41)	Zambia, Ghana	Case studies	UNICEF sponsored human-centred design initiatives were used to identify population segments that share beliefs and motivations regarding COVID-19 vaccination and community-informed strategies were developed to adress hesitance and boost acceptance.	Vaccine acceptance and uptake	Acceptability
(78)	Botswana	Report	Corbevax vaccine was developed without patent, allowing vaccine manufacturers in several low income countries to produce it without payment.	Regulatory preparedness	Availability
				Costing and funding	Availability
(68)	Global	Commentary	Overbooking appointments, appointment-free vaccination, maximising the number of doses being extracted from the vial, proper surplus donations and reallocations are necessary to address vaccine wastage.	Supply chain and health care waste	Sustainability
(84)	Africa	Systematic review	International cooperation and policy making on modifiable factors could promote the acceptability and accessibility. Affordability is addressed since individuals are not	Vaccine acceptance and uptake	Acceptability

			required to pay for the vaccine.		
(60)	Nigeria	Cross-sectional study	Most pharmacists would accept to be vaccinated and recommend and administer it to other citizens.	Human resource management and training	Sustainability
(30)	Nigeria	Commentary	Military involvement in vaccination programs can be important in conflict affected zones.	Vaccination delivery strategies	Accessibility
(82)	Kenya	Activity-based costing analysis	Estimates cost drivers of the COVID-19 delivery strategy.	Costing and funding	Sustainability
(59)	Ghana	Case study	Multisectoral synergy can accelerate vaccine adoption.	Planning, coordination and simulation exercises	Sustainability
(67)	Zimbabwe	Mixed methods study	Occupational risk perception, mandatory vaccination and communicational engagement allowed for high uptake among healthcare workers.	Human resource management and training	Sustainability
(79)	Global	Commentary	Global solidarity is needed to ensure vaccine equity. References to TRIP agreement, COVAX, the G-20 Financial Intermediary Fund for Pandemic Preparedness and Response and Global Health Threats Board, IHR revisions and robust accountability mechanisms for multisectoral stakeholders.	Costing and funding	Availability
				Regulatory preparedness	Availability
(31)	South Sudan	Case-study	Demonstrates effectiveness of mobile medical teams reducing morbidity and mortality while deploying vaccination services.	Vaccination delivery strategies	Accessibility
(80)	Afghanistan, Angola, Brazil, Cameroon, Chad, the Democratic People's Republic of Korea, Democratic Republic of Congo, Ethiopia, India,	Report	Mapping of external funding opportunities to promote donor coordination regarding immunization recovery.	Costing and funding	Availability

	Indonesia, Madagascar, Mexico, Mozambique, Myanmar, Nigeria, Pakistan, the Philippines, Somalia, Tanzania, and Vietnam				
(32)	Angola	Report	Social mobilizers, political will, vaccination hubs and pre-registration system with monitoring capability are some of the best practices atributted to Angola.	Vaccination delivery strategies	Accessibility
				Immunization monitoring systems	Sustainability
				Vaccine acceptance and uptake	Acceptability
(45)	Mozambique	Cross-sectional study	Assesses vaccine acceptability and its determinants and suggests there is a need to educate the general population about SARS-CoV-2 vaccination and its importance.	Vaccine acceptance and uptake	Acceptability
(61)	Mozambique	Report	Optimization tool for routing and scheduling to efficiently distribute vaccines.	Supply chain and health care waste	Sustainability
(39)	Mozambique	Cohort survey	Institutional trust is a important driver of vaccine acceptance.	Vaccine acceptance and uptake	Acceptability
(85)	Malawi	Comentary	Trust in government, religious or traditional leaders, social mobilization and media can be important to enhance coverage.	Vaccine acceptance and uptake	Acceptability
(62)	Mauritius, Rwanda	Report	Reference to simulation exercises in advance, provision of PPE to vaccination teams, building on existing experience and infrastructure from other diseases, use of international guidelines and the importance of broad partnerships at the national, district and local levels, and with international and business partners.	Planning, coordination and simulation exercises	Sustainability
(28)	Liberia	Report	COVID-19 vaccines were integrated into routine immunization and primary health services	Vaccination delivery strategies	Accessibility

			through expansion of cold chain system, logistical support for vaccine transportation, and integration tools such as microplanning booklets and ledgers, printers, cartridges and generators.		
(40)	Sierra Leone	Report	Experience on former diseases, community collaborations led by respected leaders and partnerships with WHO for operational oversight for implementation was relevant to increase coverage.	Vaccine acceptance and uptake	Acceptability
				Planning, coordination and simulation exercises	Sustainability
(33)	South Africa	Report	Reference to mobile health teams and grassroots approach for enhancing of vaccination coverage.	Vaccination delivery strategies	Accessibility
(63)	Mozambique	Report	International partnership with WHO, Gavi, UNICEF, US and World Bank allowed for healthcare workers training and technical support.	Human resource management and training	Sustainability
(34)	Ghana	Report	Dedicated medical boats and training of health workers and community-based volunteers allowed vaccination to reach 322 communities.	Human resource management and training	Sustainability
				Vaccination delivery strategies	Accessibility